Direct Simulations Of Nonlinear Three-Dimensional Wave and Wave-Group Dynamics

Dick K.P. Yue
Department of Ocean Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139
phone: (617) 253- 6823 fax: (617) 253-8125 email: yue@mit.edu
Award #: N000149810790

LONG-TERM GOAL

The ultimate goal is to develop effective and robust computational tools for nonlinear dynamics of three-dimensional waves. Of particular interests are the spatial/temporal coherence of such waves and the nonlinear mechanism of such coherent structures.

OBJECTIVES

The objectives are to develop and improve the efficiency of two complementary computational methods, a high-order spectral method (HOS) and a fully-nonlinear mixed-Eulerian-Lagrangian (MEL) approach, for long-time large-domain wavefield evolutions; to develop methodologies for data assimilation using HOS/MEL simulations; and to obtain three-dimensional spatial/temporal wave coherence, structures and their mechanisms.

APPROACH

Direct computations by HOS and MEL methods are performed to obtain assessment and understanding of the mechanism and coherence of steep three-dimensional ocean waves. The two computational methods are complementary: HOS provides large-scale three-dimensional simulations which also serve to corroborate experimental and field data, confirm perturbation predictions, and identify local wave events and episodes of interests; while MEL obtains detailed fully-nonlinear three-dimensional wave kinematics/dynamics for specific local episodic events.

WORK COMPLETED

The project has started for just a few months, during which a multiple-level iterative scheme for wave reconstruction using HOS/MEL optimization has been developed and tested. The completion of this work is essential for data assimilation and proper specification of the initial conditions for HOS/MEL simulations.

RESULTS

Some preliminary studies are conducted on wave reconstruction of two-dimensional wave fields. Figure 1 shows the comparison of the specified wave probe record and the HOS simulation result for about 10 dominant wave periods . The agreement between them is excellent.

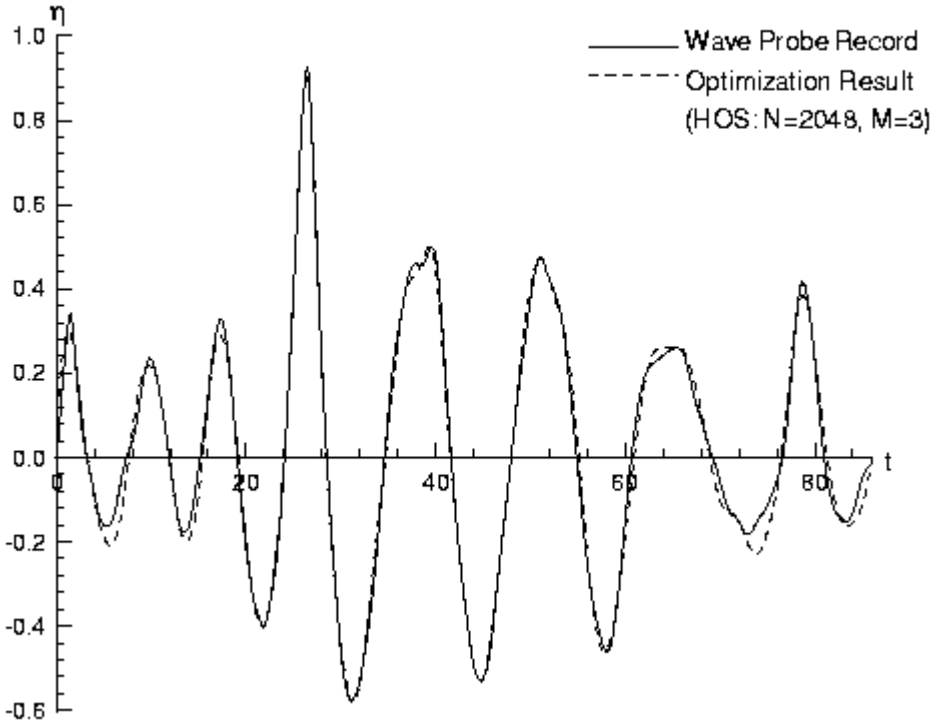

Figure 1. Comparison of computed versus experimentally measured free-surface elevation (*10 meters) at a given point as a function of time (seconds) of a two-dimensional wavefield: _____, experiments of Stansberg et al. 1995; - - - -, HOS simulation with N=2048 spectral modes and M=3 order.

IMPACT/APPLICATION

The understanding and modeling of steep three-dimensional wave evolutions are essential to the design and safety of very large floating structures such as the proposed Mobile Offshore Base (MOB).

FUTURE WORKS:

The planned immediate tasks include to:

- Improve the efficiency of HOS/MEL
- Accelerate the convergence of wave reconstruction optimization
- Generalize wave reconstruction to full three-dimensions and multiple measurement points
- Perform Monte Carlo simulations of wave spectrum evolution using HOS

REFERENCES

Stansberg, C.T., Huse, E., Krokstad, J.R., and Lehn, E. 1995 Experimental study of nonlinear loads on vertical cylinders in steep random waves. Proc. 5th ISOPE Conference, the Hague, the Netherlands.